Progress in evaluating carotid artery stenosis

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If cloth is expensive, measure it seven times before you cut.

—an old Russian proverb

Transient ischemic attacks and minor strokes are undisputed and serious risk factors for subsequent ischemic stroke, and recent randomized surgical trials have indicated that, when feasible, carotid endarterectomy is by far the best method of preventing strokes in patients with these symptoms.[1] In the North American Symptomatic Carotid Endarterectomy Trial (NASCET),[2] the annual ipsilateral stroke rate was reduced from 12% in the medical group to 4.5% in the carotid endarterectomy group in patients with carotid artery stenosis. Similar figures in the European Carotid Surgery Trial (ECST)[3] indicate an eightfold reduction in ipsilateral ischemic stroke after carotid artery surgery. The critical threshold of carotid artery stenosis, measured angiographically in both studies, was 70%; below this level, results remain inconclusive, and data are still being collected.

Unfortunately it soon became apparent that, because of different methods of measuring linear diameter stenosis on angiography, there were serious disagreements between the two studies. Bousser,[4] for instance, pointed out that the same patient evaluated by the ECST method would have a 77% carotid artery stenosis, whereas in the NASCET the stenosis would be only 40%. This means that if patients in Europe had development of symptoms, they would warrant carotid endarterectomy, but if they were in North America, they would be treated conservatively because the surgical threshold had not been reached. Attempts to reconcile these two methods indicate similar event curves,[5] but although they can be approximated by an arithmetic correction,[6] as yet no unified scale has appeared to simplify this problem. Because of this lack of consensus, both methods continue to be used independently in different geographical centers, resulting in marked disparities in surgical treatment.

One problem with both methods is that the site of stenosis, invariably the carotid bulb, is compared with the distal internal carotid artery (ICA) as in NASCET, or a reconstructed image of the bulb itself (ECST). Because the bulb is a larger denominator than the ICA, a discrepancy arises. However, this is not the only problem. The angiographic image of the distal ICA is subject to several artifacts such as poststenotic collapse of the distal artery, overlapping vessels, or simply inadequate views of the area. When 114 carotid angiographic films of patients with symptomatic carotid artery disease were evaluated "blindly" by three different observers, the NASCET method could only be used correctly in 89%, and ECST in 95%. A further 9% of NASCET stenoses were recorded as "negative" because the stenosis diameter was greater than the normal distal ICA.[7]

To overcome these problems attempts have been made to measure carotid artery stenosis by different methods. In 1986, Williams and Nicolaides[8] compared the ICA bulb with the common carotid arteries (CCA) in 60 normal angiograms and found a relatively constant relationship of 1.19 ± 0.09 (the bulb being the larger). This allows a predicted dimension of the carotid bulb to be calculated and compared with the actual stenosis to derive a percentage value. It is easier to measure because the proximal CCA is more clearly seen on angiography and is usually free from atherosclerosis. Also, this method has the least interobserver and intraobserver error, least individual variation, and correlates best with ultrasound measurements and carotid artery plaque disease.[7] A similar method, to compare the distal CCA with the bulb, also compares favorably with the two established methods.[6] However, we believe the proximal CCA to be a better denominator, because the diameter of distal portion, directly

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adjacent to the carotid bulb, is highly variable and often involved in the same atheroma.[9]

One unfortunate observation from the NASCET study was the apparent inaccuracy of carotid artery ultrasound measurements when compared with the "gold standard" of angiography.[5] The study was not designed to test this technique, so the discrepancies between this method and standard angiography are post hoc findings, interesting only to generate hypotheses for future studies. Carotid artery duplex scanning is a safe, inexpensive, and totally noninvasive method of screening patients for the presence of carotid artery stenosis, characteristics not shared by carotid angiography. In the right hands, it has a sensitivity and specificity of 95%,[10] but it is admittedly more subject to operator variability than standard angiography. Also, ultrasonography measures blood flow velocities proportionate to the cross-sectional area of the vessel and approximates the actual stenosis measured at carotid artery surgery, whereas angiography, even with biplanar views, measures linear, diametric stenosis, so is only accurate with a perfectly round lumen. It tends to underestimate the actual narrowing of the artery, producing more an "index" of stenosis rather than reflecting reality; in the absence of clear biplanar views, angiography can be disastrously inaccurate.[7]

This is not simply an academic consideration, because with recent developments in neurovascular imaging, there is increasing enthusiasm to evaluate the carotid arteries totally noninvasively. Even today, there remains a relatively high stroke and death rate from conventional angiography variously estimated at 1% to 4%.[11] Unfortunately both magnetic resonance angiography and carotid artery duplex scanning consistently misinterpret high-grade carotid artery stenoses over 90%. A false-positive rate of 7.5% for carotid artery occlusion by these methods[12] is unacceptable, because they would cause rejection of patients with a high risk of stroke who are otherwise good surgical candidates. A false-negative rate would prove even more disastrous if the carotid artery was dissected out at operation only to prove occluded and so inoperable. Some compromise can be achieved, because a combination of color-coded carotid artery duplex scanning and magnetic resonance angiography can at least exclude from further angiography patients with insignificant carotid artery stenoses, reserving it only for those with carotid artery stenoses over 90% in whom noninvasive methods are less reliable.[13] As suggested by the NASCET and ECST investigators, the search must continue for a noninvasive method that correlates with a percentage angiographic stenosis, and so avoid further angiographic morbidity.[5]

It is clearly impractical at this stage to consider changing the two present indexes of carotid artery stenosis, despite limitations with reliability and reproducibility, even if they do not reflect true structural stenosis. Both studies represent major advances in neurovascular surgery by changing clinical practice in stroke prevention and will probably never be repeated. However, their evaluation has revealed the shortcomings of present angiographic methods of measuring carotid artery stenosis. Newer, more reliable techniques for evaluating angiographic stenosis should be used in future studies of patients with carotid artery stenosis,[6,7,14] until noninvasive methods become sufficiently developed to supplant them.

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